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Lee

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(54) **THROUGH-HOLE LAYOUT STRUCTURE INCLUDING FIRST AND SECOND PAIRS OF DIFFERENTIAL SIGNAL THROUGH-HOLES DISPOSED BETWEEN THREE GROUND THROUGH-HOLES**

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H05K 1/02 (2006.01)
H05K 1/11 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 1/0216*** (2013.01); ***H05K 1/0245*** (2013.01); ***H05K 1/115*** (2013.01); *H05K 2201/042* (2013.01); *H05K 2201/10189* (2013.01)

(58) **Field of Classification Search**
CPC H05K 1/0245; H05K 1/0216
USPC 333/4, 5, 12
See application file for complete search history.

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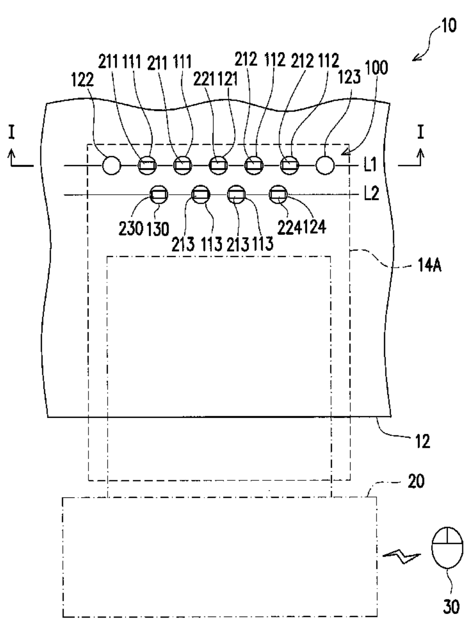
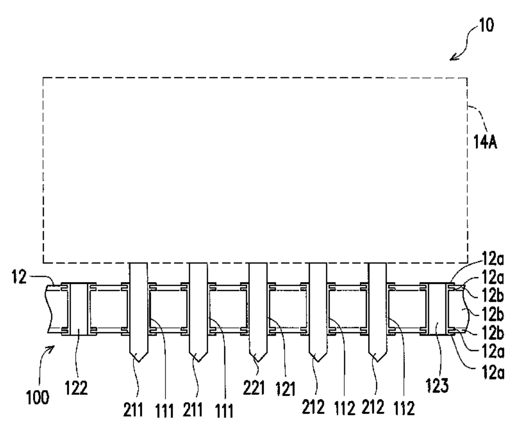
(57) **ABSTRACT**

A through-hole layout structure is suitable for a circuit board. The through-hole layout structure includes a pair of first differential through-holes, a pair of second differential through-holes, a first ground through-hole, a second ground through-hole, and a third ground through-hole, which are all arranged on a first line. The first ground through-hole is located between the pair of first differential through-holes and the pair of second differential through-holes. The pair of first differential through-holes is located between the first ground through-hole and the second ground through-hole. The pair of second differential through-holes is located between the first ground through-hole and the third ground through-hole.

21 Claims, 4 Drawing Sheets





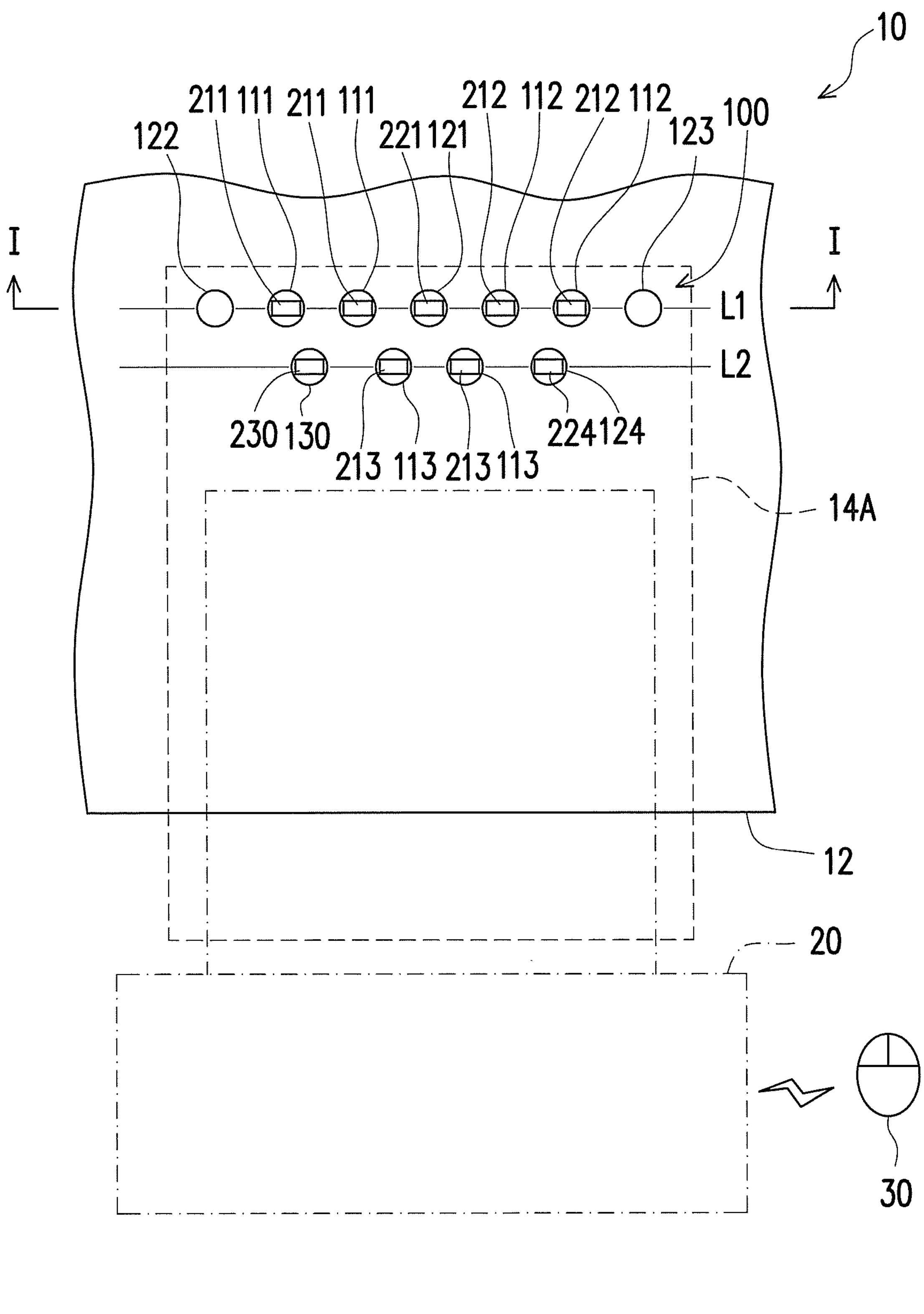
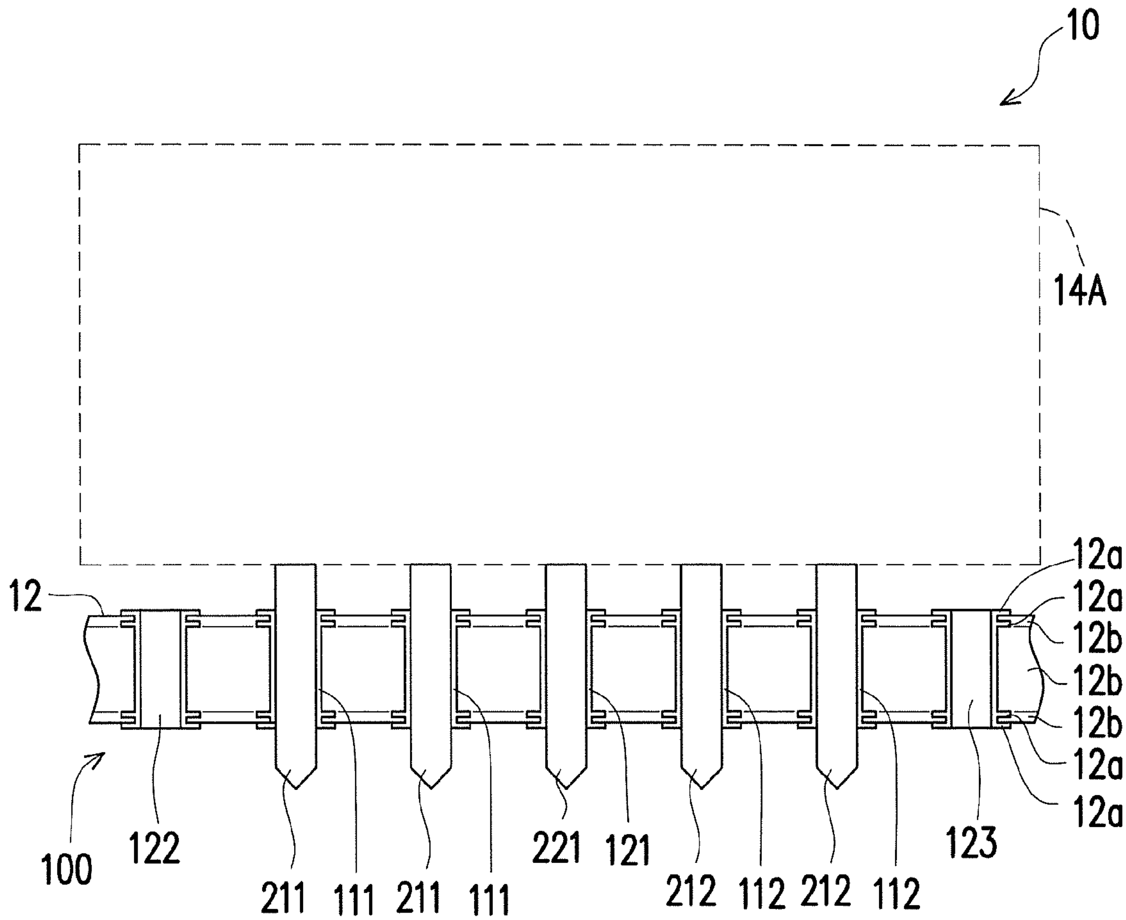
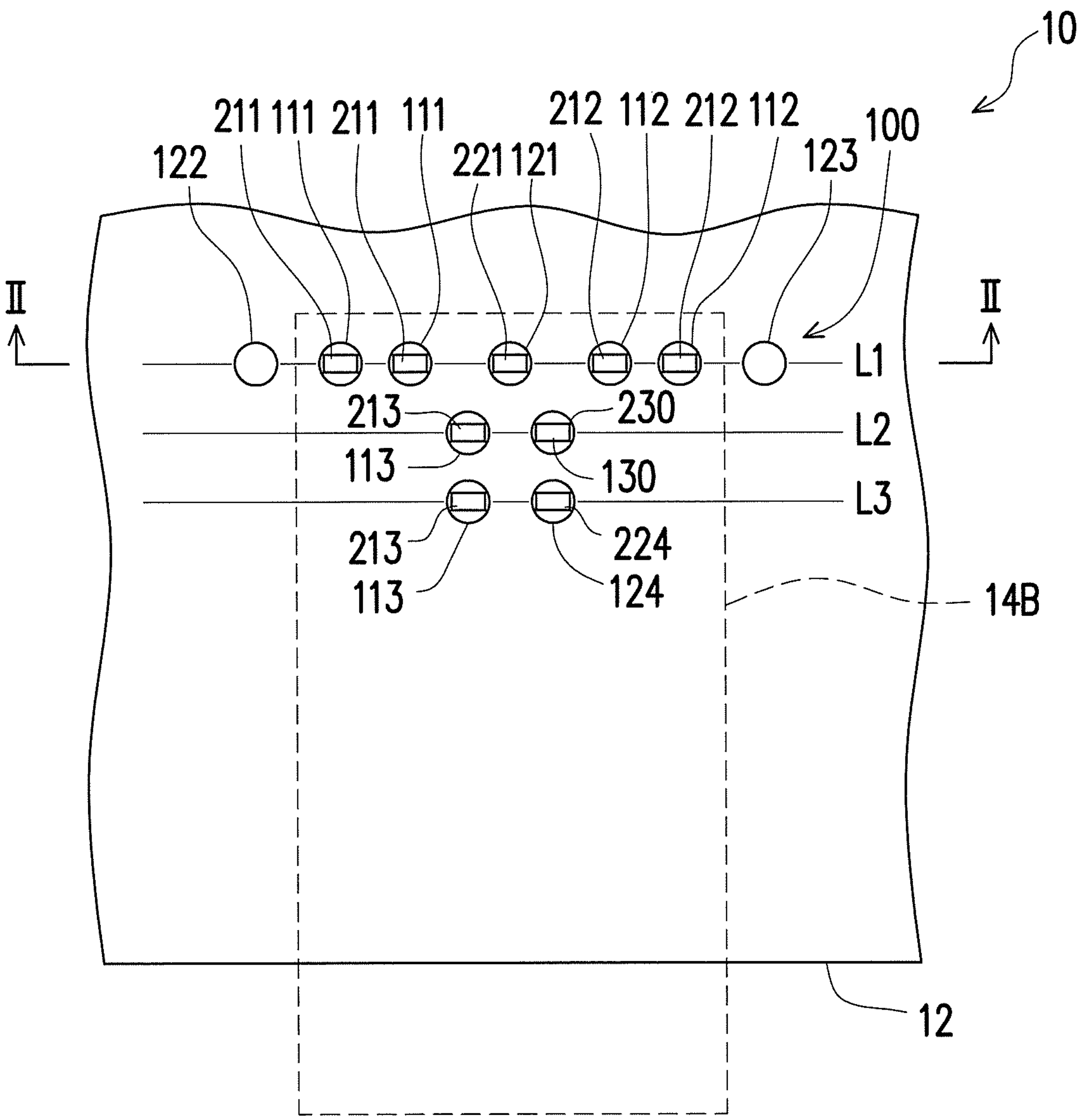

10
211 111 211 111
212 112 212 112
122
221 121
123 100
I
I
L1
L2
230 130
213 113 213 113
224 124
14A
12
20
30

FIG. 1A



10
14A
12
12a
12a
12b
12b
12b
12a
12a
100
122
211
111
211
111
221
121
212
112
212
112
123

FIG. 1B



10
211 111 211 111
212 112 212 112
100
122
221 121
123
II
II
L1
213
230
L2
113
130
L3
213
224
113
124
14B
12

FIG. 2A

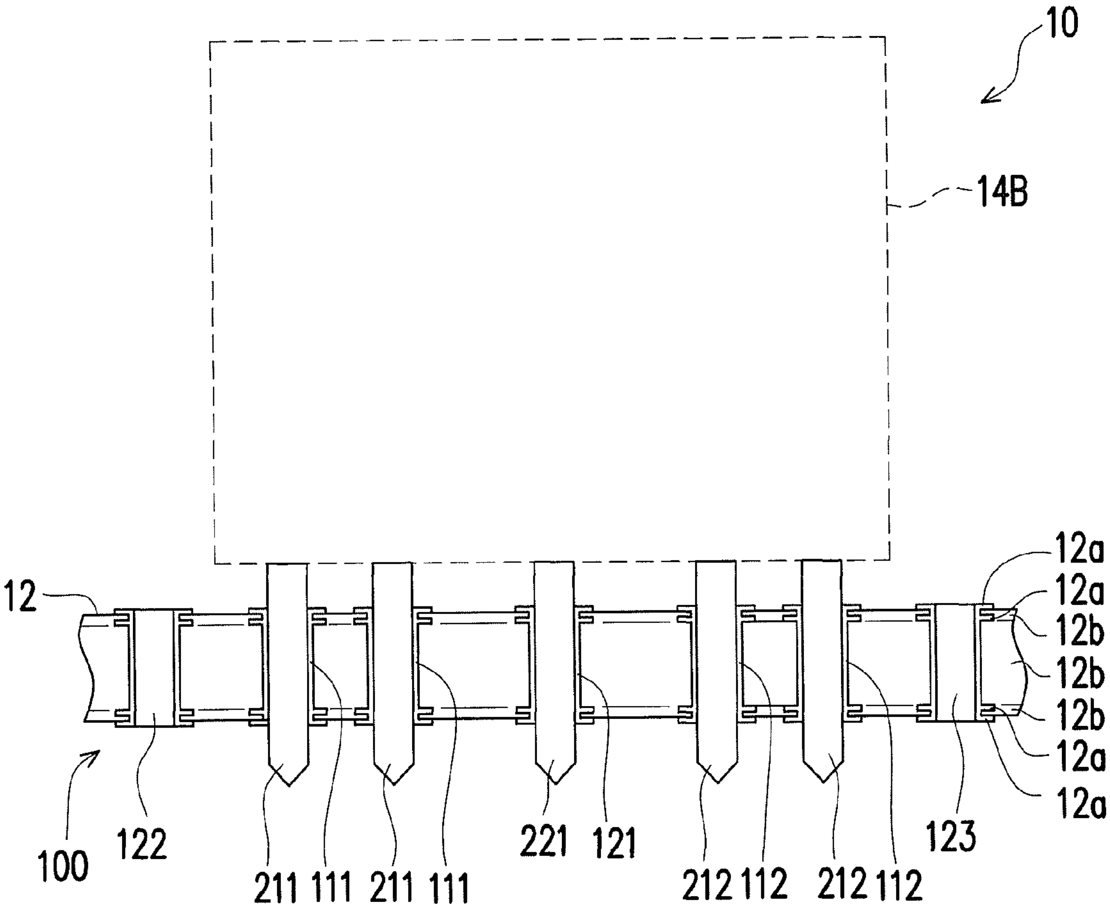

10
14B
12
12a
12a
12b
12b
12b
12a
12a
100
122
211
111
211
111
221
121
212
112
212
112
123

FIG. 2B

THROUGH-HOLE LAYOUT STRUCTURE INCLUDING FIRST AND SECOND PAIRS OF DIFFERENTIAL SIGNAL THROUGH-HOLES DISPOSED BETWEEN THREE GROUND THROUGH-HOLES

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefits of U.S. provisional application Ser. No. 62/025,992, filed on Jul. 17, 2014 and Taiwan application serial no. 103131781, filed on Sep. 15, 2014. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a circuit board, and more particularly, to a through-hole layout structure suitable for a circuit board and used to reduce signal interference, and a circuit board and an electronic assembly adopting the through-hole layout structure.

2. Description of Related Art

The application of the current Universal Serial Bus 3.0 (USB 3.0) is widely used. However, issues of electromagnetic interference (EMI)/radio frequency interference (RFI) may occur at a frequency of about 2.5 GHz. The reason is, USB 3.0 has a data rate of 5 Gbps and the clock frequency thereof is 2.5 GHz. Therefore, an apparatus (such as the wireless module of a wireless mouse) at an operating frequency of about 2.5 GHz may fail due to interference from the signal on an USB 3.0.

For instance, the hub of USB 3.0 has a circuit board and a USB 3.0 chip and a USB 3.0 electrical connector installed on the circuit board. When a plastic material is adopted for the casing of the hub of the USB 3.0 and a suitable metal shield is absent, the RFI emitted by the USB 3.0 signal (clock frequency of 2.5 GHz) transmitted by the circuit board is about 2.5 GHz. Such EMI/RFI may affect the wireless module of a wireless mouse at an operating frequency of 2.4 GHz.

A method of differential signal is adopted for the architecture on an USB 3.0 for signal transmission. A differential transmission path needs to have good symmetry to ensure balance of the differential signal. When the differential transmission path is asymmetric, the differential signal may be converted to an undesired common mode noise, thereby causing the issue of RFI.

SUMMARY OF THE INVENTION

The invention is directed to a through-hole layout structure suitable for a circuit board and used to reduce external interference generated when a signal is transmitted.

The invention is directed to a circuit board used to reduce external interference generated when a signal is transmitted.

The invention is directed to an electronic assembly used to reduce external interference generated when a signal is transmitted.

A through-hole layout structure of the invention is suitable for a circuit board. The through-hole layout structure includes a pair of first differential through-holes, a pair of second differential through-holes, a first ground through-hole, a second ground through-hole, and a third ground through-hole, which are all arranged on a first line. The first ground through-hole is located between the pair of first differential through-holes and the pair of second differential through-holes. The pair of first differential through-holes is located between the first ground through-hole and the second ground through-hole. The pair of second differential through-holes is located between the first ground through-hole and the third ground through-hole.

A circuit board of the invention is suitable for installing an electrical connector. The circuit board includes a plurality of patterned conductive layers, a plurality of dielectric layers alternately stacked with the patterned conductive layers, and the through-hole layout structure.

An electronic assembly of the invention includes the circuit board and an electrical connector installed on the circuit board. The electrical connector includes a pair of first differential pins, a pair of second differential pins, and a first ground pin. The pair of first differential pins is respectively plugged into the pair of first differential through-holes. The pair of second differential pins is respectively plugged into the pair of second differential through-holes. The first ground pin is plugged into the ground through-hole.

Based on the above, in the invention, in the case that one side of each pair of differential through-holes has a ground through-hole, by adding a ground through-hole to the other side of each pair of differential through-holes, each pair of differential through-holes can electrically reference the two ground through-holes of the two terminals thereof. Therefore, the added ground through-hole facilitates the maintenance of the symmetry of a differential transmission path so as to reduce common mode noise converted by each pair of differential through-holes.

In order to make the aforementioned features and advantages of the disclosure more comprehensible, embodiments accompanied with figures are described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic of an electronic assembly of an embodiment of the invention.

FIG. **1**B is a cross-sectional schematic of a portion of the electronic assembly of FIG. **1**A along line I-I.

FIG. **2**A is a schematic of an electronic assembly of another embodiment of the invention.

FIG. **2**B is a cross-sectional schematic of a portion of the electronic assembly of FIG. **2**A along line II-II.

DETAIL DESCRIPTION OF THE PREFERRED EMBODIMENTS

The same reference numerals are used throughout the drawing figures to denote same or like parts, and its designation thereof may not necessarily be repeated in the following detail description. Referring to FIG. **1**A and FIG. **1**B, in the present embodiment, an electronic assembly **10** includes a circuit board **12** and an electrical connector **14**A installed on the circuit board **12**. A Universal Serial Bus 3.0 (USB 3.0) or Universal Serial Bus 3.1 (USB 3.1) chip (not shown) can further be installed on the circuit board **12**, and the USB 3.0 or USB 3.1 chip is electrically connected to the electrical connector **14**A via the circuit board **12**. The circuit board **12** includes a plurality of patterned conductive layers **12***a* and a plurality of dielectric layers **12***b*, and the patterned conductive layers **12***a* and the dielectric layers **12***b* are alternately stacked, as shown in FIG. **1**B. To install the electrical connector **14**A on the circuit board **12**, the circuit board **12** includes a plurality of through-holes, and a plurality of pins of the electrical connector **14**A are respectively plugged into the through-holes.

In the present embodiment, the electrical connector **14**A is a standard A-type receptacle connector of USB 3.0 or USB 3.1. Therefore, the electrical connector **14**A includes a pair of first differential pins **211**, a pair of second differential pins **212**, and a first ground pin **221**. Correspondingly, the circuit board **12** includes a through-hole layout structure **100** including a pair of first differential through-holes **111**, a pair of second differential through-holes **112**, and a first ground through-hole **121**. The pair of first differential pins **211** is respectively plugged into the pair of first differential through-holes **111**. The pair of second differential pins **212** is respectively plugged into the pair of second differential through-holes **112**. The first ground pin **221** is plugged into the first ground through-hole **121**.

According to the arrangement of the pins of the electrical connector **14**A, the pair of first differential through-holes **111**, the pair of second differential through-holes **112**, and the first ground through-hole **121** are arranged on a first line L**1** (FIG. **1**A). The first ground through-hole **121** is located between the pair of first differential through-holes **111** and the pair of second differential through-holes **112**. Moreover, the pair of first differential through-holes **111** transmits a pair of differential signals Tx+ and Tx− on an USB 3.0 or on an USB 3.1, and the pair of second differential through-holes **112** transmits a pair of differential signals Rx+ and Rx− on an USB 3.0 or on an USB 3.1.

To ensure the symmetry of a differential transmission path, the through-hole layout structure **100** further includes a second ground through-hole **122** and a third ground through-hole **123**. The second ground through-hole **122** and the third ground through-hole **123** are also arranged on the first line L**1**. The pair of first differential through-holes **111** is located between the first ground through-hole **121** and the second ground through-hole **122**. The pair of second differential through-holes **112** is located between the first ground through-hole **121** and the third ground through-hole **123**. Therefore, in addition to electrically referencing the first ground through-hole **121**, the pair of first differential through-holes **111** further electrically references the second ground through-hole **122**. Similarly, in addition to electrically referencing the first ground through-hole **121**, the pair of second differential through-holes **112** further electrically references the third ground through-hole **123**. Therefore, the second ground through-hole **122** and the third ground through-hole **123** facilitate the maintenance of the symmetry of a differential transmission path, and do not provide plugging of any pin of the electrical connector **14**A. The additional disposition of the second ground through-hole **122** and the third ground through-hole **123** is different from the current art, in which only the first ground through-hole **121** used as a single electrical reference is disposed.

Moreover, since the standard A-type receptacle connector of USB 3.0 or USB 3.1 is compatible with the signal transmission on an Universal Serial Bus 1.0 (USB 1.0) or on an Universal Serial Bus 2.0 (USB 2.0), the electrical connector **14**A further includes a pair of third differential pins **213**, a power pin **230**, and a second ground pin **224** as shown in FIG. **1**A. Correspondingly, the through-hole layout structure **100** of the circuit board **12** further includes a pair of third differential through-holes **113**, a power through-hole **130**, and a fourth ground through-hole **124** as shown in FIG. **1**A. The pair of third differential pins **213** is respectively plugged into the pair of third differential through-holes **113**. The power pin **230** is plugged into the power through-hole **130**. The second ground pin **224** is plugged into the fourth ground through-hole **124**.

According to the pin arrangement of the electrical connector **14**A, the pair of third differential through-holes **113** is arranged on a second line L**2** substantially parallel to the first line L**1** (FIG. **1**A). The power through-hole **130** is arranged on the second line L**2**. The fourth ground through-hole **124** is arranged on the second line L**2**. The pair of third differential through-holes **113** is arranged between the power through-hole **130** and the fourth ground through-hole **124**. Moreover, the pair of third differential through-holes **113** transmits a pair of transmission/reception differential signals D+ and D− on an USB 1.0 or on an USB 2.0.

In general, the transmission/reception differential signal terminals (D+ and D−) are in a half-duplex transmission mode, that is, only one of transmission or reception of a signal can be performed. That is, when data transmission is performed, data reception cannot be performed; and when data reception is performed, data transmission cannot be performed. Moreover, in the architecture of USB 3.0 or USB 3.1, the transmission differential signal terminals (Tx+ and Tx−) and the reception differential signal terminals (Rx+ and Rx−) are in a full-duplex transmission mode, that is, transmission or reception of a signal can be directly performed.

Further referring to FIG. **1**A, in the present embodiment, a wireless module **20** corresponding to a wireless mouse **30** can be plugged into the electrical connector **14**A. Signal is transmitted in a wireless manner between the wireless module **20** and the wireless mouse **30**. Therefore, when the clock frequency (2.5 GHz) of a signal transmitted by the pair of first differential through-holes **111** and the pair of second differential through-holes **112** of FIG. **1**A is substantially equal to or close to the operating frequency (2.4 GHz) of the wireless module **20**, the pair of first differential through-holes **111** can electrically reference the first ground through-hole **121** and the second ground through-hole **122**, and the pair of second differential through-holes **112** can electrically reference the first ground through-hole **121** and the third ground through-hole **123**. Therefore, the second ground through-hole **122** and the third ground through-hole **123** facilitate the maintenance of the symmetry of a differential transmission path so as to reduce common mode noise converted by the pair of first differential through-holes **111** and the pair of second differential through-holes **112**. As a result, RFI to the wireless module **20** is reduced, such that the wireless mouse **30** can perform normal operation.

Referring to FIG. **2**A and FIG. **2**B, the electronic assembly **10** of FIG. **2**A and FIG. **2**B is similar to the electronic assembly **10** of FIG. **1**A and FIG. **1**B. The differences between the two are as described below. First, the electrical connector **14**A of FIG. **1**A and FIG. **1**B is a standard A-type receptacle connector of USB 3.0 or USB 3.1, and an electrical connector **14**B of FIG. **2**A and FIG. **2**B is a standard B-type receptacle connector of USB 3.0 or USB 3.1. Therefore, in FIG. **1**A and FIG. **1**B, the second ground through-hole **122** and the third ground through-hole **123** are overlapped on an orthographic projection of the electrical connector **14**A on the circuit board **12**. However, in FIG. **2**A and FIG. **2**B, the second ground through-hole **122** and the third ground through-hole **123** are not overlapped on an orthographic projection of the electrical connector **14**B on the circuit board **12**. It should be mentioned that, the second ground through-hole **122** and the third ground through-hole **123** facilitate the maintenance of the symmetry of a differential transmission path, and do not provide plugging of any pin of the electrical connector **14**A. The additional disposition of the second ground through-hole **122** and the third ground through-hole **123** is different from the current art, in which only the first ground through-hole **121** used as a single electrical reference is disposed.

Moreover, as shown in FIG. **2**A, according to the pin arrangement of the electrical connector **14**B (that is, standard B-type receptacle connector of USB 3.0 or USB 3.1), the power through-hole **130** and one of the pair of third differential through-holes **113** are arranged on a second line L**2** substantially parallel to the first line L**1**. The fourth ground through-hole **124** and the other one of the pair of third differential through-holes **113** are arranged on a third line L**3** substantially parallel to the first line L**1**.

Based on the above, in the invention, in the case that one side of each pair of differential through-holes has a ground through-hole, by adding a ground through-hole to the other side of each pair of differential through-holes, each pair of differential through-holes can electrically reference the two ground through-holes of the two terminals thereof. Therefore, the added ground through-hole facilitates the maintenance of the symmetry of a differential transmission path so as to reduce common mode noise converted by each pair of differential through-holes. In terms of adopting USB 3.0 (clock frequency at 2.5 GHz) as a transmission protocol apparatus (such as a hub) and an apparatus for which the current operating frequency is at 2.5 GHz, the invention can reduce external interference generated by the apparatus itself so as to reduce RFI to a wireless apparatus (such as the wireless module of a wireless mouse) at an operating frequency of 2.4 GHz (close to 2.5 GHz).

Although the invention has been described with reference to the above embodiments, it will be apparent to one of the ordinary skill in the art that modifications to the described embodiments may be made without departing from the spirit of the invention. Accordingly, the scope of the invention is defined by the attached claims not by the above detailed descriptions.

What is claimed is:

1. A through-hole layout structure, suitable for a circuit board, the through-hole layout structure comprising:
- a pair of first differential through-holes arranged on a first line;
- a pair of second differential through-holes arranged on the first line;
- a first ground through-hole arranged on the first line, wherein the first ground through-hole is located between the pair of first differential through-holes and the pair of second differential through-holes;
- a second ground through-hole arranged on the first line, wherein the pair of first differential through-holes is located between the first ground through-hole and the second ground through-hole; and
- a third ground through-hole arranged on the first line, wherein the pair of second differential through-holes is located between the first ground through-hole and the third ground through-hole.

2. The through-hole layout structure of claim **1**, wherein the pair of first differential through-holes electrically references the first ground through-hole and the second ground through-hole, the pair of second differential through-holes electrically references the first ground through-hole and the third ground through-hole, and the second ground through-hole and the third ground through-hole do not provide plugging of a pin of an electrical connector.

3. The through-hole layout structure of claim **1**, further comprising:
- a pair of third differential through-holes arranged on a second line substantially parallel to the first line;
- a power through-hole arranged on the second line; and
- a fourth ground through-hole arranged on the second line, wherein the pair of third differential through-holes is located between the power through-hole and the fourth ground through-hole.

4. The through-hole layout structure of claim **3**, wherein the pair of first differential through-holes transmits a pair of transmission differential signals Tx+ and Tx− on a first USB 3.0 or on a first USB 3.1, the pair of second differential through-holes transmits a pair of transmission differential signals Rx+ and Rx− on a second USB 3.0 or on a second USB 3.1, and the pair of third differential through-holes transmits a pair of transmission/reception differential signals D+ and D− on an USB 1.0 or on an USB 2.0.

5. The through-hole layout structure of claim **1**, further comprising:
- a pair of third differential through-holes;
- a power through-hole arranged on a second line substantially parallel to the first line with one of the pair of third differential through-holes arranged on the second line; and
- a fourth ground through-hole arranged on a third line substantially parallel to the first line with the other one of the pair of third differential through-holes arranged on the third line.

6. The through-hole layout structure of claim **5**, wherein the pair of first differential through-holes transmits a pair of transmission differential signals Tx+ and Tx− on a first USB 3.0 or on a first USB 3.1, the pair of second differential through-holes transmits a pair of transmission differential signals Rx+ and Rx− on a second USB 3.0 or on a second USB 3.1, and the pair of third differential through-holes transmits a pair of transmission/reception differential signals D+ and D− on an USB 1.0 or on an USB 2.0.

7. A circuit board, suitable for installing an electrical connector, the circuit board comprising:
- a plurality of patterned conductive layers;
- a plurality of dielectric layers alternately stacked with the plurality of patterned conductive layers; and
- a through-hole layout structure, comprising:
  - a pair of first differential through-holes arranged on a first line of the plurality of patterned conductive layers;
  - a pair of second differential through-holes arranged on the first line;
  - a first ground through-hole arranged on the first line, wherein the first ground through-hole is located between the pair of first differential through-holes and the pair of second differential through-holes;
  - a second ground through-hole arranged on the first line, wherein the pair of first differential through-holes is located between the first ground through-hole and the second ground through-hole; and
  - a third ground through-hole arranged on the first line, wherein the pair of second differential through-holes is located between the first ground through-hole and the third ground through-hole.

8. The circuit board of claim **7**, wherein the pair of first differential through-holes electrically references the first ground through-hole and the second ground through-hole, the pair of second differential through-holes electrically references the first ground through-hole and the third ground through-hole, and the second ground through-hole and the third ground through-hole do not provide plugging of a pin of the electrical connector.

9. The circuit board of claim **7**, wherein the through-hole layout structure further comprises:

a pair of third differential through-holes arranged on a second line of the plurality of patterned conductive layers substantially parallel to the first line;

a power through-hole arranged on the second line; and

a fourth ground through-hole arranged on the second line, wherein the pair of third differential through-holes is located between the power through-hole and the fourth ground through-hole.

10. The circuit board of claim **9**, wherein the pair of first differential through-holes transmits a pair of transmission differential signals Tx+ and Tx− on a first USB 3.0 or on a first USB 3.1, the pair of second differential through-holes transmits a pair of transmission differential signals Rx+ and Rx− on a second USB 3.0 or on a second USB 3.1, and the pair of third differential through-holes transmits a pair of transmission/reception differential signals D+ and D− on an USB 1.0 or on an USB 2.0.

11. The circuit board of claim **7**, wherein the through-hole layout structure further comprises:

a pair of third differential through-holes;

a power through-hole arranged on a second line of the plurality of patterned conductive layers substantially parallel to the first line and with one of the pair of third differential through-holes arranged on the second line; and

a fourth ground through-hole arranged on a third line of the plurality of patterned conductive layers substantially parallel to the first line and with the other one of the pair of third differential through-holes arranged on the third line.

12. The circuit board of claim **11**, wherein the pair of first differential through-holes transmits a pair of transmission differential signals Tx+ and Tx− on a first USB 3.0 or on a first USB 3.1, the pair of second differential through-holes transmits a pair of transmission differential signals Rx+ and Rx− on a second USB 3.0 or on a second USB 3.1, and the pair of third differential through-holes transmits a pair of transmission/reception differential signals D+ and D− on an USB 1.0 or on an USB 2.0.

13. An electronic assembly, comprising:

a circuit board, comprising:

a plurality of patterned conductive layers;

a plurality of dielectric layers alternately stacked with the plurality of patterned conductive layers; and

a through-hole layout structure, comprising:

a pair of first differential through-holes arranged on a first line of the plurality of patterned conductive layers;

a pair of second differential through-holes arranged on the first line;

a first ground through-hole arranged on the first line, wherein the first ground through-hole is located between the pair of first differential through-holes and the pair of second differential through-holes;

a second ground through-hole arranged on the first line, wherein the pair of first differential through-holes is located between the first ground through-hole and the second ground through-hole; and

a third ground through-hole arranged on the first line, wherein the pair of second differential through-holes is located between the first ground through-hole and the third ground through-hole; and

an electrical connector installed on the circuit board, the electrical connector comprising:

a pair of first differential pins respectively plugged into the pair of first differential through-holes;

a pair of second differential pins respectively plugged into the pair of second differential through-holes; and

a first ground pin plugged into the first ground through-hole.

14. The electronic assembly of claim **13**, wherein the pair of first differential through-holes electrically references the first ground through-hole and the second ground through-hole, the pair of second differential through-holes electrically references the first ground through-hole and the third ground through-hole, and the second ground through-hole and the third ground through-hole do not provide plugging of a pin of the electrical connector.

15. The electronic assembly of claim **13**, wherein the through-hole layout structure further comprises:

a pair of third differential through-holes arranged on a second line of the plurality of patterned conductive layers substantially parallel to the first line;

a power through-hole arranged on the second line; and

a fourth ground through-hole arranged on the second line, wherein the pair of third differential through-holes is located between the power through-hole and the fourth ground through-hole, and the electrical connector further comprises:

a pair of third differential pins respectively plugged into the pair of third differential through-holes;

a power pin plugged into the power through-hole; and

a second ground pin plugged into the fourth ground through-hole.

16. The electronic assembly of claim **15**, wherein the pair of first differential through-holes transmits a pair of transmission differential signals Tx+ and Tx− on a first USB 3.0 or on a first USB 3.1, the pair of second differential through-holes transmits a pair of transmission differential signals Rx+ and Rx− on a second USB 3.0 or on a second USB 3.1, and the pair of third differential through-holes transmits a pair of transmission/reception differential signals D+ and D− on an USB 1.0 or on an USB 2.0.

17. The electronic assembly of claim **15**, wherein the second ground through-hole and the third ground through-hole are overlapped on an orthographic projection of the electrical connector on the circuit board.

18. The electronic assembly of claim **13**, wherein the through-hole layout structure further comprises:

a pair of third differential through-holes;

a power through-hole arranged on a second line of the plurality of patterned conductive layers substantially parallel to the first line and with one of the pair of third differential through-holes arranged on the second line; and

a fourth ground through-hole arranged on a third line of the plurality of patterned conductive layers substantially parallel to the first line and with the other one of the pair of third differential through-holes arranged on the third line, and the electrical connector further comprises:

a pair of third differential pins respectively plugged into the pair of third differential through-holes;

a power pin plugged into the power through-hole; and

a second ground pin plugged into the fourth ground through-hole.

19. The electronic assembly of claim **18**, wherein the pair of first differential through-holes transmits a pair of transmission differential signals Tx+ and Tx− on a first USB 3.0 or on a first USB 3.1, the pair of second differential through-holes transmits a pair of transmission differential signals Rx+ and Rx− on a second USB 3.0 or on a second USB 3.1, and the pair of third differential through-holes transmits a pair of transmission/reception differential signals D+ and D− on an USB 1.0 or on an USB 2.0.

20. The electronic assembly of claim **18**, wherein the second ground through-hole and the third ground through-hole are not overlapped on an orthographic projection of the electrical connector on the circuit board.

21. The electronic assembly of claim **13**, wherein the electrical connector is suitable for plugging a wireless module, and an operating frequency of the wireless module is substantially the same as a clock frequency of a signal transmitted by the pair of first differential through-holes or the pair of second differential through-holes.

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